United Technologies

WRITTEN STATEMENT OF
WILLIAM T. MILLER
PRESIDENT
INTERNATIONAL FUEL CELLS
SENATE COMMERCE, SCIENCE AND TRANSPORTATION COMMITTEE

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Good morning. My name is William Miller. I'm the President of International Fuel Cells (IFC), a subsidiary of United Technologies Corporation (UTC). UTC is based in Hartford, Connecticut and provides a broad range of high-technology products and support services to the building systems and aerospace industries. UTC's products include Carrier air conditioners, Otis elevators and escalators, Pratt & Whitney jet engines, Sikorsky helicopters, Hamilton Sundstrand aerospace systems and fuel cells by International Fuel Cells.

IFC has a long history in fuel cells. We've produced the fuel cells for every U.S. manned space mission since 1966, including the Space Shuttle. These fuel cells produce the electricity for the orbiter when it is in space and all the drinking water for the astronauts. IFC is also the only company in the world currently producing a commercially available fuel cell power plant. That unit, the PC25™, produces 200 kilowatts, which is enough to power roughly 150 homes. Currently, these units power schools, hospitals, military installations, data processing centers and other facilities.

Fuel cell technology is a reality today in space and commercial/industrial applications. By the end of this decade it will also power homes, cars, trucks and buses.

Fuel cells offer great potential for addressing climate change. Current fuel cell technology using hydrocarbon feed stocks produces 60% more electricity per pound of carbon dioxide emissions than the average US combustion based power generating system. Using hydrogen as the fuel will enable us to eliminate CO_2 emissions from the fuel cell power plant's operation.

Unlike other environmentally favorable solutions such as solar or wind power, fuel cells can be used as a continuous source of base power – independent of time-of-day or weather - for critical facilities, thereby offloading demand and providing independence from the grid.

FUEL CELL DESCRIPTION

Fuel cells are an electrochemical device that combines hydrogen and oxygen to produce electricity, with only water and heat as the by-products. Fuel cells do not

use combustion to create electricity. It is combustion that creates NOx, which is responsible for smog, and SOx, which is responsible for acid rain.

IFC HISTORY AND CURRENT FUEL CELL APPLICATIONS

International Fuel Cells is the world leader in fuel cell production and development for commercial, transportation, residential and space applications. IFC is the sole supplier of fuel cells for U.S. manned space missions and is the only company in the world producing a commercial fuel cell system, the PC25^{TM} power plant.

IFC's headquarters, research and development, and manufacturing facilities are located in South South Windsor, Connecticut and cover more than 350,000 square feet. IFC employs some 750 engineers, researchers, managers and production workers.

Since 1966, IFC fuel cells have provided electrical power, as well as drinking water, for more than 250 astronauts on all of the United States' manned space flights. Each space shuttle mission carries three IFC 12-kilowatt fuel cell units. These units have accumulated more than 81,000 hours of fuel cell operating experience.

IFC is also the only company in the world currently producing a commercially available fuel cell power plant. That unit, the PC25, produces 200 kilowatts, which is enough to power roughly 150 homes. IFC has delivered more than 220 PC25s to customers in 16 countries and five continents.

This PC25 fleet of fuel cells has accumulated more than 4 million hours of operational experience in a range of operating environments. The PC25 system requires only routine maintenance and has a life of 40,000 hours, or five years, before a major overhaul is required. IFC has 32 PC25s operating in states represented by Senators on the Commerce, Science and Transportation Committee.

IFC is now developing fuel cell technology for residential/light commercial and transportation applications, including buses, fleet vehicles and cars.

ENVIRONMENTAL AND CLIMATE CHANGE BENEFITS OF FUEL CELLS

When pure hydrogen is the fuel source, fuel cells produce no harmful emissions--no carbon dioxide, which is the primary man-made greenhouse gas involved in global warming and no NOx or SOx, the pollutants that cause smog and acid rain.

Hydrogen is not yet readily available as a fuel. Because of this, fuel cell power plants incorporate fuel processors to reform commonly available hydrocarbons such as natural gas, propane, or methane from waste water treatment plants into hydrogen fuel.

Even when running on these hydrocarbons, IFC's fuel cells are still very climate friendly and efficient. They produce 60% more electricity per pound of carbon dioxide emission than the average US combustion based power generating system.

IFC'S installed base of PC25 power plants has already prevented nearly 800 million pounds of CO_2 emissions and more than 14.5 million pounds of NO_x and SO_x compared with typical US combustion-based power plants. The U.S. Environmental Protection Agency recognized IFC last year with a Climate Protection Award in recognition of these accomplishments.

FUEL CELLS ARE MORE EFFICIENT ENERGY PRODUCERS

Fuel cells, because they do not use combustion, are significantly more efficient, meaning they produce more energy from the same amount of fuel

For example, in the "electricity-only" mode of operation, IFC's PC25 unit achieves approximately 40% efficiency. However, fuel cells are generally installed at the point of use, so the waste heat from the fuel cell can be used for such things as space heating. This is known as co-generation. When used in co-generation applications, the PC25 can reach efficiencies as high as 87%.

FUEL CELLS FOR DISTRIBUTED GENERATION

Distributed generation is increasingly being recognized as one way to address both the need to reduce the demand on the current electric distribution system and to provide assured power at facilities such as data centers where uninterruptible power is a requirement.

As our society increases its reliance on sophisticated computer systems, very short power interruptions can have profound economic consequences. In 1996 the Electric Power Research Institute reported that US businesses lose $29 billion annually from computer failures due to power outages and lost productivity.

Locating distributed generation assets at the point of use also eliminates transmission line losses that can run as high as 15%.

Fuel cells are an excellent distributed power asset because they are clean, quiet and small enough to provide power at the point of use. For example, two IFC PC25s are located *inside* the Conde Nast skyscraper at Four Times Square in New York City.

IFC's PC25s are used in a number of installations in this capacity. Some examples:

- The Central Park Police Station in New York City uses a PC25 to provide all the power for the facility on a "24-7" basis completely independent of the grid.
- In Rhode Island, a PC25 system provides power for the South County Hospital. The installation supplies base load electrical and thermal energy to the hospital where it helps ensure clean, reliable power for sensitive medical equipment and systems such as CAT scanners, monitors, analyzers, and laboratory test equipment. If there is a grid outage, the PC25 automatically operates as an independent system, continuing to power critical loads at the hospital. Heat from the installation provides energy for space heating, increasing the fuel cell's overall efficiency.
- The largest commercial fuel cell system in the world is currently operating at a U.S. Postal Service mail-processing center facility in Anchorage, Alaska. The

PC25 units operate in parallel to the grid and are owned and operated by the local utility. The fuel cells can either provide power to the U.S. Postal Service or provide power back to the grid. If the grid fails, a near instantaneous switching system automatically disconnects the grid and allows the fuel cells to provide uninterrupted power.

- One of IFC's installations at the First National Bank of Omaha involves four fuel cells as the major component of an integrated assured power system that is meeting customer requirements for 99.9999% reliability.
- A number of schools and colleges in Massachusetts, New York and New Jersey have purchased fuel cells to ensure clean, efficient, and reliable power for data processing and computer operations, provide basic electricity and heating needs as well as use the units as a teaching tool for students. For example, Cape Cod Community College expects its fuel cell to help save the college about $54,000 of the $185,000 in energy costs each year. This fuel cell power plant installation is part of a comprehensive energy savings performance contract agreement being implemented by NORESCO.

As these examples illustrate, fuel cells are very flexible in meeting customers' power requirements for base load, assured power, emergency back up and co-generation. In addition, fuel cells are being used in grid connected, grid independent and grid parallel applications.

RENEWABLE ENERGY

Fuel cells are already using renewable energy sources.

IFC and the US Environmental Protection Agency (EPA) collaborated in the early 1990s on a greenhouse gas mitigation program that continues to bear fruit today. Initial efforts targeted landfills and the development of gas cleanup systems that enable fuel cells to use waste methane to generate electricity and resulted in the issuance of several patents jointly held by EPA and IFC. These systems avoid the use of fossil fuels as the fuel source.

Follow-on work has focused on anaerobic digester off-gases (ADGs) from wastewater treatment facilities. This technology has been implemented successfully at PC25 installations in Yonkers, New York; Calabasas, California; Boston, Massachusetts; and Portland, Oregon as well as Cologne, Germany and Tokyo, Japan.

RESIDENTIAL AND LIGHT COMMERCIAL FUEL CELL APPLICATION

IFC, along with several other companies, is currently pursuing residential and light commercial fuel cell applications for homes and businesses using next-generation proton exchange membrane (PEM) fuel cell technology.

IFC is drawing on its experience in commercial programs to develop a five-kilowatt PEM fuel cell system suitable for homes and small commercial buildings. IFC is teaming up with its sister UTC unit Carrier Corp., the world's largest maker of air conditioners, as well as Toshiba Corp. of Japan and Buderus Heiztechnik of Germany on this effort.

IFC is currently testing residential power plants and plans to have residential fuel cells units commercially available in 2003. Initial markets will include off-grid residential (an estimated 150,000 Americans live off the grid today), telecommunications providers who need assured power for cell towers and public buildings such as fire stations that required assured power.

TRANSPORTATION FUEL CELL APPLICATIONS

In the transportation arena, IFC is aggressively developing quiet, highly efficient ambient-pressure PEM fuel cells and gasoline reformation technology for automobiles, heavy-duty trucks and bus applications. Fuel reforming technology allows fuel cells to operate on pump gasoline.

IFC is currently working with major automobile manufacturers, including BMW and Hyundai and with the U.S. Department of Energy on development and demonstration programs for automobiles.

Last year, for example, IFC replaced the internal combustion engine in a Hyundai Santa Fe Sport Utility Vehicle with its zero emission Series 300 75-kilowatt hydrogen powered fuel cell. This vehicle was featured at the grand opening ceremony of the California Fuel Cell Partnership on November 1, 2000. This is the world's first zero emission SUV and gets the gasoline equivalent of 50 to 60 miles per gallon. Pure water vapor is the only by-product of this fuel cell power system. Hyundai and IFC have put two fuel cell powered Santa Fe's into driving service in California.

The IFC vehicle power plant is quiet and efficient. It's unique because it uses a near ambient pressure system, which substantially increases its efficiency. Other transportation fuel cells require a compressor, which is a parasitic drain on the system because it uses part of the electricity produced by the fuel cell.

The IFC system has fewer parts, which translates into lower costs for the consumer and is smaller and hence easier to put in a car. To date, we have demonstrated the following capabilities with the IFC/Hyundai Santa Fe fuel cell vehicle:

- Performs with undetectable noise levels;
- Achieves maximum power output of 75 kW and a top speed in excess of 70 mph;
- Fills the vehicle's fuel tank with hydrogen to a pressure of roughly 3,000 psi in less than 3 minutes; and
- No infringement on passenger or cargo space.

In addition, IFC has also developed fuel cell auxiliary power units (APUs) that can power all the electronic components of a car thus removing this heavy power demand from the engine. In 1999, BMW demonstrated at the Frankfurt Auto Show a Series-7 vehicle featuring a 5-kilowatt hydrogen IFC fuel cell that powered the onboard electrical systems and air conditioning. During the two-week exhibition, we

used the APU to run the car's lights and radio continuously without the engine running.

For buses, IFC has teamed with Thor Industries, the largest mid-size bus builder in North America and Irisbus, one of the largest European bus manufacturers, to build fuel cell powered zero emission transit buses. These prototype vehicles will take to the road this year.

HYDROGEN FUTURE

Fuel cells are already beginning to bring forth the clean, renewable, hydrogen future.

Some examples:

- IFC's hydrogen fuel cells have been used in space applications since 1966.
- IFC operated a 200-kilowatt fuel cell unit in Germany running on hydrogen.
- BMW has incorporated a hydrogen fuel cell auxiliary power unit into a Series 700 automobile.
- IFC has installed hydrogen-powered fuel cells into four Hyundai Santa Fe sports utility vehicles.
- IFC is developing hydrogen fuel cell buses with US and European partners.

Buses and fleet vehicles, since they return to a central location each day, are a near term opportunity to create the necessary hydrogen infrastructure including production, distribution and storage capability.

Meanwhile, a number of companies are making substantial progress on hydrogen production and storage. Ultimately, the vision is to produce hydrogen for diverse fuel cell applications through the use of renewable energy such as hydroelectric, solar and wind power.

CHALLENGES

The cost of fuel cells has been one of the greatest impediments to their commercial use. However, the costs have been reduced dramatically in the past two decades. The space shuttle fuel cells, developed in the late 1970s, cost roughly $600,000 per kW. The PC25 commercial stationary unit, which was developed in the early 1990, has an installed cost today of $4,500 per kilowatt.

IFC and other fuel cell companies are now developing new fuel cells that are smaller, lighter and cheaper to produce. This new technology, along with higher production volume, should help reduce the cost of fuel cell power plants by two-thirds by 2003, from $4,500 a kilowatt to $1,500. The cost of fuel cells will continue to trend down. If we achieve the goal of automotive production, the cost may decline to as low as $50 per kilowatt.

GOVERNMENT ACTIONS

There are a number of things the federal government can do to help accelerate the commercialization of fuel cell technology. These include providing financial

incentives, eliminating regulatory barriers, funding government purchases and demonstration programs and continuing the nation's commitment to hydrogen research and development.

SUMMARY

Fuel cell technology represents an important component of the solution to climate change. This technology is already reducing carbon dioxide emissions and using methane as a fuel source. By the end of the decade, fuel cells will power homes, cars, trucks, buses and businesses. Widespread commercialization of fuel cells and establishment of the necessary hydrogen infrastructure will enable a wide spectrum of energy applications to eliminate their emissions of greenhouse gases without sacrificing our standard of living. Fuel cells powered by hydrogen that is produced using renewable energy is the long-term vision, and substantial progress has already been made. We look forward to working with Members of the Senate Commerce Committee and other stakeholders to ensure this vision becomes a reality.

Thank you, Mr. Chairman.